TITANIUM

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A sluggish world economy resulted in reduced demand for titanium mineral concentrate and titanium dioxide (TiO_2) pigment in 2003. Although excess mine capacity was available, expectations for future shortfalls in the supply of mineral feedstock fueled the development of new projects. One domestic producer was in the process of expanding mine capacity. World consumption of TiO_2 pigment was estimated to be 4.1 million metric tons (Mt), a slight decrease compared with that of 2002 (TZ Minerals International Pty. Ltd. Mineral Sands Report, 2004). Domestic consumption of TiO_2 pigment decreased by 4% compared with that of 2002. Weak demand by the commercial aerospace industry continued to have an effect on the titanium metal industry. Domestic shipments of mill products decreased by 4% compared with those of 2002.

Legislation and Government Programs

The Defense National Stockpile Center (DNSC) continued the sale of titanium sponge held in the National Defense Stockpile (NDS). In fiscal year (FY) 2003, the DNSC sold 6,350 metric tons (t) of sponge from the NDS. In addition, the DNSC transferred 250 t of sponge from the NDS to the U.S. Department of the Army's Tank and Automotive Command for use in the weight-reduction portion of the main battle tank upgrade program. FY 2003 is the eighth and final year of the upgrade program. Although this material was provided without charge, the Army was responsible for transportation and handling costs. At yearend 2003, the NDS held 6,420 t of titanium sponge (Defense National Stockpile Center, 2004§[1]).

The Defense Advanced Research Projects Agency's (DARPA) titanium initiative was funding the development of new methods for producing and processing titanium metal and its alloys. In April, the DARPA selected Titanium Metals Corp. (Timet) to lead a group of contractors in the development of the Fray-Farthing-Chen Cambridge process (Titanium Metals Corp., 2004§).

At the request of a Russian producer, the U.S. Department of Homeland Security's U.S. Customs and Border Protection announced a decision to reclassify imports of titanium billet from the unwrought category to the wrought category. This change was made effective for merchandise entered into or withdrawn from the warehouse for consumption on or after February 1, 2004. Although the normal tariff rates for wrought and unwrought titanium were identical (15% ad valorem), wrought products from Russia were subject to the Generalized System of Preferences (GSP) program and entered the United States duty-free (U.S. Department of Homeland Security, U.S. Customs and Border Protection, 2003§).

The Office of the U.S. Trade Representative (USTR) denied petitions to grant GSP status to imports of unwrought titanium from Russia and Kazakhstan. Kazakhstan's Ust-Kamenogorsk Titanium Magnesium Combine was the major supplier of titanium sponge to the United States. Russia's unwrought petition was submitted in 1997. Since the time of submittal, Russia has become a minor supplier of sponge into the United States. In a separate action, the USTR deferred a decision on a petition to remove Russian wrought titanium from the list of articles eligible for duty-free treatment under the GSP (American Metal Market, 2003).

Production

Mineral Concentrates.—Titanium mineral concentrates of economic importance include ilmenite, leucoxene, rutile, titaniferous slag, and synthetic rutile. Mining of titanium minerals is usually performed using surface methods. Dredging and dry mining techniques are used for the recovery of heavy-mineral sand deposits. Gravity spirals are used to separate the heavy minerals suite, while magnetic and high-tension separation circuits are used to separate the heavy-mineral constituents. Ilmenite is often beneficiated to produce synthetic rutile or titaniferous slag. Although numerous technologies are used to produce synthetic rutile, nearly all are based on either selective leaching or thermal reduction of iron and other impurities in ilmenite. Titaniferous slag with a TiO_2 content of 75% to 95% is produced commercially using pyrometallurgical processes.

U.S. mineral concentrate producers were E.I. du Pont de Nemours & Co. Inc. (DuPont), Iluka Resources Inc. (a subsidiary of Iluka Resources Ltd.), and Kerr-McGee Corp.

DuPont's mining operations near Starke, FL, produced a mixed product containing ilmenite, leucoxene, and rutile that was used as a feedstock in DuPont's TiO_2 pigment operations. In 2003, DuPont donated nearly 65 square kilometers of land adjacent to the Okefenokee Swamp National Wildlife Refuge in Georgia to The Conservation Fund. DuPont had acquired the land with the intent to expand its mining operations into Georgia; however, the project was suspended in 1997 because of environmental concerns (E.I. du Pont de Nemours and Co. Inc., 2004§).

Iluka's mining operation near Green Cove Springs, FL, produced rutile and ilmenite concentrates using dredging and dry mining techniques. At yearend, a project to expand the feed-rate of the mobile concentrator at Green Cove Springs to 500 metric tons per

[1]References that include a section mark (§) are found in the Internet References Cited section.

hour (t/hr) from 350 t/hr neared completion. Compared with 2002, Iluka's production of ilmenite and rutile in Florida increased by 14% and 19%, respectively. In Virginia, the company produced ilmenite concentrate through dry mining techniques at its Old Hickory operation near Stony Creek.   In 2003, Iluka began an optimization project at its Old Hickory operation. Compared with 2002, Iluka's production of ilmenite in Virginia increased by 37% (Iluka Resources Ltd., 2004a§).

Kerr-McGee produced synthetic rutile using the Benilite process (a hydrochloric acid beneficiation process that leaches iron from ilmenite) at its Mobile, AL, operation. However, in June, Kerr-McGee idled the Mobile plant because titanium feedstock could be purchased more economically than it could be produced at Mobile. Prior to its closure, the plant supplied a significant portion of the rutile feedstock for the company's domestic TiO_2 pigment plants. The Mobile plant was the only domestic source of synthetic rutile and had capacity to produce up to 200,000 metric tons per year (t/yr) of synthetic rutile. Feedstock into the Mobile plant was from domestic and foreign sources (Kerr-McGee Corp., 2004§).

Metal.—Commercial production of titanium metal involves the chlorination of titanium-containing mineral concentrates to produce titanium tetrachloride ($TiCl_4$), which is reduced with magnesium (Kroll process) or sodium (Hunter process) to form a commercially pure form of titanium metal. As the metal is formed, it has a porous appearance and is referred to as sponge. Titanium ingot is produced by melting titanium sponge or scrap or a combination of both, usually with various other alloying elements, such as aluminum and vanadium. Electron beam, plasma, scull, and vacuum-arc reduction are the commercial melting methods used to produce ingot. Titanium mill products are produced from the drawing, forging, and rolling of titanium ingot or slab into products of various sizes and shapes. These mill products include billet, pipe and tube, plate, rod and bar, sheet, strip, and wire. Titanium castings are produced by investment casting and rammed graphite mold casting. Ferrotitanium is usually produced by induction melting of titanium scrap with iron or steel. The two standard grades of ferrotitanium that are normally produced contain 40% and 70% titanium.

U.S. producers of titanium sponge in 2003 were The Alta Group and Timet. Alta's 340-t/yr plant produced titanium sponge by the Hunter process and supported the company's production of electronic-grade titanium. Timet's 8,600-t/yr plant produced titanium sponge by the Kroll process combined with vacuum distillation (table 2). Data on domestic production of titanium sponge are not published in order to avoid disclosing company proprietary data. About 20% of the 86,700 t/yr of domestic ingot capacity was based on cold hearth technology; the remainder used vacuum-arc reduction. As demand for titanium metal products began to rise, U.S. production of ingot soared to 35,500 t, a 56% increase compared with that of 2002. Production of mill products lagged behind ingot production increasing by only 7% compared with those of 2002 (table 3). U.S. producers of ferrotitanium were Galt Alloys Inc. and Global Titanium Inc. Data on production of ferrotitanium were not available.

Allegheny Technologies Inc. and Russian-based VSMPO—AVISMA (Verkhnaya Salda Metallurgical Production Association—Berezniki Titanium-Magnesium Works) formed a joint venture to produce and market a range of industrial commercially pure titanium products. The new joint venture, Uniti LLC, was expected to target markets that include chemical and petroleum processing, power generation, desalination, pulp and paper, construction and architecture, automotive and transportation, and consumer and electronics (Allegheny Technologies Inc., 2003§).

TiO_2 Pigment.—TiO_2 pigment is produced from titanium mineral concentrates by either the chloride process or the sulfate process. In the sulfate process, ilmenite or titanium slag is reacted with sulfuric acid. Titanium hydroxide is then precipitated by hydrolysis, filtered, and calcined. In the chloride process, rutile is converted to $TiCl_4$ by chlorination in the presence of petroleum coke. $TiCl_4$ is oxidized with air or oxygen at about 1,000° C, and the resulting TiO_2 is calcined to remove residual chlorine and any hydrochloric acid that may have formed in the reaction. Aluminum chloride is added to the $TiCl_4$ to assure that virtually all the titanium is oxidized into the rutile crystal structure. Although either process may be used to produce pigment, the decision to use one process instead of the other is based on numerous factors, including raw material availability, freight, and waste disposal costs. In finishing operations, the crude form of the pigment is milled to produce a controlled distribution of particle size and surface treated or coated to improve its functional behavior in different media. Some typical surface treatments include alumina, organic compounds, and silica.

TiO_2 pigment produced by either process is categorized by crystal form as either anatase or rutile. Rutile-type pigment is less reactive with the binders in paint when exposed to sunlight than is the anatase type and is preferred for use in outdoor paints. Anatase pigment has a bluer tone than the rutile type, is somewhat softer, and is used mainly in indoor paints and in paper manufacturing. Depending on the manner in which TiO_2 pigment is produced and subsequently finished, TiO_2 pigment can exhibit a range of functional properties, including dispersion, durability, opacity, and tinting.

U.S. production of TiO_2 pigment in 2003 was 1.42 Mt, slightly higher than that in 2002. U.S. producers of TiO_2 pigment were DuPont, Kerr-McGee, Louisiana Pigment Co. LP (an NL Industries Inc. and Huntsman Corp. joint venture), and Millennium Inorganic Chemicals Inc. (MIC) (table 4). TOR Minerals International Inc. produced a buff pigment from finely ground synthetic rutile. Capacity utilization for the domestic pigment industry was about 88%.

Kerr-McGee reported that process modifications boosted production capacity at its two domestic TiO_2 pigment operations. Improvements in oxidation technology resulted in a 25,000-t/yr capacity increase at its TiO_2 operation in Hamilton, MS, bringing capacity to 225,000 t/yr. At Savannah, GA, production capacity increased to 110,000 t/yr from 85,000 t/yr (Paint & Coatings Industry, 2003§).

Consumption

Mineral Concentrates.—On a gross weight basis, 98% of the domestic consumption of titanium mineral concentrates was used to produce TiO_2 pigment. The remaining 2% was used to produce titanium metal, welding rod coatings and fluxes, and miscellaneous other products. Based on TiO_2 content, domestic consumption of titanium minerals concentrates was 1.41 Mt, a slight increase compared with that of 2002 (table 6).

Consumption data for titanium concentrates were developed by the U.S. Geological Survey from a voluntary survey of domestic operations. Of the 20 operations canvassed, 9 responded, representing 36% of the consumption data in table 6. Data for nonrespondents were estimated based on prior-year consumption with some adjustments for present-year trends.

Metal.—Titanium metal alloys are used for their high strength-to-weight ratio and corrosion resistance. Overall consumption of titanium sponge and scrap by the titanium industry increased by 8% compared with that of 2002 (table 3). Scrap supplied a calculated 46% of ingot feedstock. Estimated U.S. mill product usage by application was as follows: aerospace, 55% and nonaerospace uses, 45%. Nonaerospace uses included those in the consumer goods, marine, medical, oil and gas, pulp and paper, and specialty chemical industries.

A significant quantity of titanium in the form of sponge, scrap, and ferrotitanium is consumed in the steel and nonferrous alloy industries. Consumption by the steel industry is largely associated with the production of stainless steels and is used for deoxidation, grain-size control, and carbon and nitrogen control and stabilization. Reported consumption of titanium products in steel and other alloys was 8,820 t, an 8% increase compared with that of 2002 (table 7).

TiO_2 Pigment.—The leading uses of TiO_2 pigment, based on TiO_2 pigment shipments in the United States, were paint and coatings (56%), plastics and rubber (23%), and paper (16%) (table 8). Other uses of TiO_2 included catalysts, ceramics, coated fabrics and textiles, floor coverings, printing ink, and roofing granules.

In the paint and coatings industry, TiO_2 pigment is used in architectural, equipment, and special-purpose applications and is widely used in white and color formulations. The TiO_2 content for paint and coatings varies significantly.

In plastics, TiO_2 pigment provides opacity and acts as a barrier against ultraviolet light degradation. TiO_2 pigment often is introduced as pelletized concentrate containing up to 50% by weight TiO_2 in a carrier resin; however, liquid and dry concentrates also are used by the industry. The TiO_2 content for plastics normally ranges from 3% to 25% by weight of the finished product. Examples of plastic applications that use TiO_2 pigment include polyethylene bags and vinyl window frames.

TiO_2 pigment in paper products provides opacity and brightness. The paper industry consumes TiO_2 pigment as filler and in coatings. Paper products contain a high percentage of non-TiO_2-base minerals as filler material with the typical TiO_2 content less than 5% of the dry weight of paper. Anatase-grade pigment is preferred in the paper industry because it is less abrasive to papermaking machinery.

In the United States, apparent consumption of TiO_2 pigment was 1.07 Mt, a 4% decrease compared with that of 2002 (table 5).

Stocks

On a TiO_2 content basis, yearend consumer inventories of titanium mineral concentrates were essentially unchanged compared with those of 2002 (table 9). While consumer stocks of natural rutile and synthetic rutile decreased slightly, stocks of ilmenite and slag increased slightly compared with those of 2002.

Yearend producer stocks of TiO_2 pigment were about 156,000 t, a 7% increase compared with those of 2002. During the year, pigment stocks rose to a high of 173,000 t in May.

Owing to sales from the DNSC inventory, Government stocks of sponge fell to 6,420 t, a 52% decrease copared with that of 2002. Industry stocks of sponge decreased by 30%. Stocks of scrap and ingot increased by 15% and 19%, respectively, compared with those of 2002 (table 3).

Prices

The yearend published price range for bulk rutile mineral concentrates was $415 to $445 per metric ton, a moderate decrease compared with that of 2002. In contrast, the yearend price range for bagged rutile concentrates used in the welding rod coatings industry was $430 to $540 per ton, a moderate increase compared with that of 2002. Yearend prices of ilmenite concentrates were nearly unchanged compared with those of 2002 (table 10). Published prices for titanium slag were not available. Based on U.S. Customs Service values of imports for the entire year, the unit value of Canadian slag increased by 2%, while the unit value of South African slag decreased by 10%. The average unit value of all slag imports for 2002 decreased by 8% compared with that of 2002.

Yearend published prices for anatase- and rutile-grade pigment were nearly unchanged compared with those of 2002. Based on the quantity and value of imports, the unit value of TiO_2 pigment containing more than 80% TiO_2 increased slightly compared with those of 2002.

Based on duty-paid value of imports, the yearend value of titanium sponge was $2.72 to $3.95 per pound. A year-on-year comparison of all sponge imports shows a slight decrease in unit value. The yearend price range for titanium scrap turnings increased significantly, to between $1.50 and $1.70 per pound in 2003 from between $1.07 and $1.10 per pound in 2002. The published price increase was substantiated by a 25% increase in the duty-paid unit value of waste and scrap imports. Healthy demand for ferrotitanium by steel producers was reflected in a significant increase in ferrotitanium prices. Yearend price for ferrotitanium with 70% contained titanium was up by more than 40% compared with 2002.

Foreign Trade

Mineral Concentrates.—As opposed to imports, the United States exported a minor amount of titanium mineral concentrate. In 2003, exports of titanium mineral concentrate were 10,300 t, a 170% increase compared with 2002 (table 11).

Imports of ilmenite were 395,000 t, nearly unchanged compared with those of 2002. The leading import sources of ilmenite in 2003 were Australia (60%), Ukraine (23%), and Vietnam (10%). Based on the unit value, 18,200 t of ilmenite imports from South Africa appear to be misclassified titaniferous slag or rutile. Decreased imports of ilmenite from Malaysia were offset by increased imports from Vietnam.

Imports of titaniferous slag were 409,000 t, an 8% decrease compared with those of 2002. South Africa (86%) and Canada (14%) were the major import sources of titanium slag.

Imports of natural and synthetic rutile were 427,000 t, a 10% increase compared with those of 2002. Australia (66%) and South Africa (29%) were the major import sources of natural and synthetic rutile in 2003. Imports of natural rutile from Australia increased significantly, 91% higher compared with 2002.

Imports of titaniferous iron ore from Canada, classified as ilmenite by the U.S. Census Bureau, decreased by 48% compared with those in 2002. Titaniferous iron ore is used by the steel industry to protect the crucibles of blast furnaces. In this report, imports of titaniferous iron ore from Canada are separated from ilmenite statistics (table 12).

Metal.—Imports of titanium metal are primarily in the form of titanium sponge (47%) and waste and scrap (27%). Kazakhstan (52%) and Japan (44%) were the major sources of imported titanium sponge. Japan (27%), the United Kingdom (19%), France (17%), and Germany (12%) were the leading sources of imported waste and scrap. Owing to decreased imports from Germany and Russia, imports of ingot and billet decreased by 37%. Meanwhile, imports of other forms of titanium (including bloom, sheet bar, slab, and other unwrought) increased by 75%. Although low in volume relative to other metal forms, imports of titanium powder also significantly increased (72%) compared with those of 2002 (table 13).

Imports of wrought products and castings increased by 36% compared with those of 2002. Imports of ferrotitanium and ferrosilicon titanium, primarily used in the iron and steel industry, decreased by 15% compared with those of 2002.

Although the United States was import reliant on unwrought titanium, the Nation was a net exporter of wrought products. Compared with those of 2002, exports of wrought products and castings increased by 5% (table 11).

TiO_2 Pigment.—The United States continued to be a net exporter of TiO_2 pigment. In 2003, exports exceeded imports by a ratio of 2.4 to 1. Exports of TiO_2 pigment were 584,000 t, an 8% increase compared with that of 2002. About 89% of exports was in the form of finished pigment with more than 80% TiO_2 content.

During 2003, 240,000 t of TiO_2 pigment was imported, a 4% increase compared with the previous year (table 14). The leading import sources of TiO_2 pigment were Canada (29%), Germany (14%), France (8%), and China (8%). Compared with those of 2002, imports of TiO_2 pigment containing more than 80% TiO_2 increased by 8% to 198,000 t, of other TiO_2 pigment increased by 14% to 5,120 t, and of unfinished TiO_2 (unmixed and not surface treated) decreased by 11% to 37,600 t.

World Review

Australia, Canada, India, Norway, and South Africa continued to lead the world production of titanium mineral concentrates (table 15). The largest commercial producers of titanium mineral concentrates (in descending order) were Iluka, Richards Bay Iron and Titanium Pty. Ltd., QIT-Fer et Titane Inc., and Titania A/S. In 2003, numerous mineral sands projects were under development and had the potential to oversupply the titanium feedstock market.

Global TiO_2 pigment consumption was 4.1 Mt, a slight decrease compared with that of 2002 (TZ Minerals International Pty. Ltd. Mineral Sands Report, 2004). France, Germany, Japan, the United Kingdom, and the United States were the leading producing countries of TiO_2 pigment. The leading commercial producers of TiO_2 pigment (in descending order) were DuPont, MIC, Huntsman Corp., Kerr-McGee, Kronos Inc., and Ishihara Sangyo Kaisha, Ltd.

Titanium sponge was produced in China, Japan, Kazakhstan, Russia, Ukraine, and the United States. Major producers of titanium ingot and wrought products were located primarily in China, France, Germany, Italy, Japan, Russia, the United Kingdom, and the United States.

Australia.—A prefeasibility study was completed on BeMaX Resources NL's Pooncarie heavy-mineral sands project in the Murray Basin. The study indicated that both the Ginkgo and Snapper deposits were economically viable as separate operations, but significant economic advantages could be achieved by combining the two into a single operating entity. In 2004, BeMaX planned to begin an environmental impact statement for the project. If successful, the output of the Pooncarie project was expected to be approximately 480,000 to 500,000 t/yr of heavy-mineral concentrate (BeMaX Resources NL, 2004§).

A bankable feasibility study was underway at Gunson Resources Ltd.'s Coburn mineral sands project, located 250 kilometers (km) north of Geraldton, Western Australia. The principal activity in the study was drilling of the southern part of the Amy deposit (Gunson Resources Ltd., 2003§).

Through its acquisition of Magnetic Minerals Ltd., Ticor Ltd. acquired the Dongara mineral sands deposit in Western Australia. Ticor hoped that the development of the Dongara deposit would support production from nearby dry separation and synthetic rutile plants at Chandala. Ticor began drilling and evaluation of the Bidaminna and Mindara deposits in Western Australia during the second half of 2003. Evaluation of the Cooljarloo and Jurien deposits in Western Australia were expected to begin in 2004. In addition, Tiwest, a joint venture between Kerr-McGee and Ticor, purchased Falcon Resources Inc.'s tenements located to the north of the Cooljarloo mine. The company expected the purchase to extend the life of the Tiwest operations (Ticor Ltd., 2004§).

Mineral Deposits Ltd. ceased heavy-mineral sands dredging operations at Fullerton, New South Wales. Subsequently, the Hawks Nest dry separation plant was idled in October 2003. Dismantling of the Fullerton dredge was to begin in 2004 for redeployment to India (Mineral Deposits Ltd., 2004§).

Iluka continued development efforts in the Murray Basin. A prefeasibility study was completed on the KWR deposit near Ouyen and the Douglas project near Balmoral. The study revealed that a single mineral separation plant in Hamilton was the most effective way to process wet concentrate from Douglas and KWR. A detailed feasibility study was planned for completion in 2004. If the mine is developed, then production was expected to begin in 2005. At full production, the Douglas and KWR operations could produce 500,000 t/yr of ilmenite and 154,000 t/yr of rutile heavy-mineral concentrate (Iluka Resources Ltd., 2004b§).

Southern Titanium NL continued work on its Mindarie heavy-mineral sands project in the Murray Basin. Activities in 2003 included an engineering review of a feasibility study completed the previous year. If the project is developed, then the company intends to produce 72,000 t/yr of ilmenite, 8,200 t/yr of rutile, and 7,200 t/yr of leucoxene during a 12-year mine life (Southern Titanium NL, 2003§).

Canada.—Titanium Corp. Inc. (TCI) entered into an agreement with Syncrude Canada Ltd. and an unnamed TiO_2 pigment producer to jointly explore and develop the potential for producing titanium concentrate and zircon from oil sands process tailings. In connection with this agreement, TCI planned to construct a pilot plant in Saskatchewan using proprietary technology to produce titanium concentrate. The amount of titanium in Syncrude's process tailings could supply a significant percentage of global demand for titanium concentrate. Separately, TCI continued work on the exploration of heavy-mineral sands near Truro, Nova Scotia. The Nova Scotia Department of Natural Resources granted TCI exploration licenses for an area on the western side of Cobequid Bay (Titanium Corp. Inc., 2003§).

China.—Driven by growth in industrial output, China's production and consumption of TiO_2 pigment experienced significant growth. With only one chloride-route TiO_2 pigment producer, production of TiO_2 pigment is based on a large number of sulfate-route plants, each with capacity of 20,000 t/yr or less.

In 2003, China's production of titanium concentrates increased to keep pace with demand from TiO_2 pigment producers. Since 1999, production of titanium concentrates increased more than threefold. In 2003, production of titanium concentrate increased by 7% compared with 2002.

Zunyi Titanium Co. Ltd. was reported to be constructing a new titanium sponge plant in Guzhou. The new facility was expected to bring Zunyi's sponge capacity to 7,500 t/yr. China's sponge production in 2003 was estimated to be 4,000 t (TZ Minerals International Pty. Ltd. Inside China, 2003).

Gambia, The.—Carnegie Corp. Ltd.'s joint venture with Astron Ltd. began processing a zircon-rich stockpile at Brufut that had been created by British Titanium Products in the 1950s. In addition, the company was evaluating plans to develop the nearby titanium-bearing heavy-mineral sands deposit (Carnegie Corp. Ltd., 2003§).

India.—MDL was assisting Beach Mineral Sands Co. Pvt. Ltd. (BMC) with plans to expand and improve the recovery of heavy minerals at the Kuttam mining operation in Tamil Nadu. The expansion plan included the transfer of a section of MDL's Fullerton (Newcastle, Australia) concentrator to BMC. At yearend, construction of wet separation spirals to treat 40 t/hr of concentrate was underway (Mineral Deposits Ltd., 2004§).

Earth Mineral Resources Pvt. Ltd. (EMR) formed an agreement with Transworld Garnet India Pvt. Ltd. to extract ilmenite process tailings from its garnet operation in Tamil Nadu. EMR's ilmenite capacity was expected to be 72,000 t/yr (TZ Minerals International Pty. Ltd. Mineral Sands Report, 2003b). Shipments from this operation began in the second quarter of 2003.

V.V. Mineral commissioned a wet separation plant at its Tamil Nadu operations. The plant was designed to process 150 t/hr of ore averaging 30% to 40% heavy minerals. V.V. Mineral's mine capacity is reported to include 120,000 t/yr of ilmenite (TZ Minerals International Pty. Ltd. Mineral Sands Report, 2003b).

WGI Heavy Minerals Inc., based in Coeur d'Alene, ID, announced plans to construct a heavy-mineral sands processing plant in Andhra Pradesh. The new facility is expected to begin production of garnet, ilmenite, rutile, and zircon in 2004. WGI's proven reserves include 650,000 t of ilmenite (Minerals Engineering International, 2003§).

Japan.—According to the Japan Titanium Society, production of titanium sponge in Japan fell to 18,900 t, a 25% decrease compared with 2002. During the same period, consumption of titanium sponge decreased by 28%. Production of ingot and mill products also decreased significantly. Despite a decrease in global demand for titanium, Toho Titanium Co. Ltd. raised sponge production capacity by 1,000 t/yr to 13,000 t/yr. The increase brought Japan's sponge capacity to 31,000 t/yr (Toho Titanium Co. Ltd., 2003§).

According to the Japan Titanium Dioxide Industry Association, Japan's TiO_2 pigment production was 255,000 t, a 6% increase compared with that of 2002. TiO_2 pigment production capacity in Japan was estimated to be 346,000 t/yr (Roskill's Letter from Japan, 2004).

Kenya.—Tiomin Resources Inc. continued the development of its Kwale heavy-mineral deposit. In 2003, a pilot-plant program was conducted to determine the optimal tailings disposal method. Pilot-plant testing concluded that the settling of slimes in tailings ponds would not be an operating issue. Dry separation test work was to be completed in 2004. When commissioned, the mine is expected produce 330,000 t/yr of ilmenite and 77,000 t/yr of rutile during the first 6 years of operation (Tiomin Resources Inc., 2004§).

Madagascar.—Iluka commenced exploration on the Farafangana deposit on Madagascar's eastern coast. The deposit has the potential to be a source of high-quality ilmenite suitable for use as a synthetic rutile feedstock (Iluka Resources Ltd., 2004b§).

Ticor formed an agreement with Madagascar Resources NL (MRNL) to conduct a feasibility study on the Tulear mineral sands deposits held by MRNL in southwestern Madagascar. The agreement provides Ticor with an option to purchase MRNL's interest in the deposits after a bankable feasibility study is completed (Ticor Ltd., 2003§).

Rio Tinto continued plans for the development of its QIT Madagascar Minerals (QMM) mineral sands project near Fort-Dauphin. An investment decision on the Fort-Dauphin project was expected in 2005 (Rio Tinto plc, 2004§).

Mozambique.—WMC Resources Ltd. continued work on the development of its Corridor Sands project. In 2003, WMC undertook further engineering studies, secured permits for improved power supply, and pursued product export options. Industrial Development Corp. of South Africa exercised its option to acquire a 10% interest in the project. Construction was expected to start in 2005 with initial production to begin in 2007. At full production, Corridor Sands is expected to produce 1 million metric tons per year of titaniferous slag (TZ Minerals International Pty. Ltd. Mineral Sands Report, 2003a; WMC Resources Ltd., 2004§).

At yearend, Kenmare Resources plc. was transporting portions of the recently dismantled Beenup separation plant (Western Australia) to northeastern Mozambique for use at the Moma project. Reserves at Moma were estimated to include 16.4 Mt of ilmenite and 0.5 Mt of rutile. At yearend, Kenmare was seeking financing to begin mine construction. The Moma project is expected to produce 615,000 t/yr of ilmenite and 17,000 t/yr of rutile (Kenmare Resources plc, 2004§).

Senegal.—MDL and the Government of Senegal agreed to the development of heavy-mineral sands deposits located on a coastal strip 100 miles north of Dakar. The company hoped to build on drilling and test work DuPont had conducted during the early 1990s. At yearend, a 45-t bulk sample was being gathered from the Mboro deposit to determine the most suitable beneficiation method (Mineral Deposits Ltd., 2004§).

Sierra Leone.—Plans were underway to restart the idled Sierra Rutile operation. The Overseas Private Investment Corporation agreed to loan $25 million to Sierra Rutile Ltd. to assist with the restart of the operation. When the first phase of the project is completed, Sierra Rutile is expected to produce 110,000 t/yr of rutile and 20,000 t/yr of ilmenite (Overseas Private Investment Corporation, 2003§).

South Africa.—Following the startup of the Hillendale Mine and separation plant in 2002, Ticor SA commissioned two titaniferous slag furnaces at its Empangeni operation in KwaZulu-Natal. At full capacity, the furnaces could produce 250,000 t/yr of titaniferous slag (Zululand Observer, 2003§). Ticor is an alliance between Kumba Resources Ltd. (60%) and Ticor Ltd. (40%).

Mineral Commodities Ltd. (MCL) proceeded with the development of its Xolobeni heavy-mineral sands project located between East London and Durban. Activities in 2003 included work on the development of a resource estimate and preparations for mining approval. In addition, the company signed an agreement with the local community through Xolobeni Empowerment Co. (XEC), which would allow XEC to acquire up to 15% equity in the Xolobeni project. The proposed schedule is to commission a mine in 2007. At full production, MCL plans to produce 137,000 t of slag, 19,000 t of rutile, and 15,000 t of leucoxene (Mineral Commodities Ltd., 2004§).

Ukraine.—Zaporozhye Titanium-Magnesium Combine (ZTMC) increased production at its titanium sponge plant to 6,934 t, a 13% increase compared with 2002. At its peak, ZTMC capacity was estimated to be 20,000 t/yr (Interfax Mining & Metals Report, 2004).

Outlook

The global titanium mineral concentrate market is in the midst of change. While reserves of some established producers are dwindling, numerous projects are underway to bring new capacity into production. Without new mine capacity, demand for mineral concentrates would exceed supply within the next 5 years. However, the growth in demand is not sufficient to support the plethora of projects under development. The advent of China as a major consumer and producer of concentrates will likely have a major impact on world markets.

Because TiO_2 pigment is used in paint and coatings, paper, and plastics, TiO_2 pigment demand is closely linked to economic activity. During the next 2 years, demand is expected to increase by 2% to 3%. Plastics should continue to be the strongest growth market for TiO_2 pigment. On a regional basis, Asia is expected to be the area of strongest growth.

Commercial aerospace and defense industries compose a significant portion of demand for titanium metal. As such, large swings in demand are characteristic of the industry. In 2003, weak demand by the commercial aerospace industry was mitigated by gains demand by the defense industry. Demand in 2004 is expected to be unchanged from 2003. Long-term growth is expected to be driven by orders for commercial aircrafts. During the next 20 years, increased passenger and freight travel will necessitate orders for more than 24,000 commercial aircrafts (Boeing Co., 2004§).

New low-cost methods for producing titanium could change the dynamics within the titanium industries during the next decade. The use of titanium is primarily limited by its cost. If low-cost titanium were available, then titanium use in potentially high-volume markets, such as automotive exhaust, springs, and valves, would increase dramatically.

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TABLE 1
SALIENT TITANIUM STATISTICS[1]

(Metric tons unless otherwise specified)

		1999	2000	2001	2002	2003
United States:						
Ilmenite and titaniferous slag:						
Imports for consumption		1,070,000	918,000	1,060,000	840,000	804,000
Consumption[2]		1,280,000	1,250,000	1,180,000	1,300,000	1,300,000
Rutile concentrate, natural and synthetic:						
Imports for consumption		344,000	438,000	325,000	390,000	427,000
Consumption		494,000	537,000	483,000	487,000	489,000
Sponge metal:						
Imports for consumption		6,000	7,240	13,300	10,700	9,590
Consumption		18,100	18,200	26,200	17,300	16,800
Price, yearend[3]	dollars per pound	3.58	3.95	3.58	3.64	2.72-3.95
Titanium dioxide pigment:						
Production		1,350,000	1,400,000	1,330,000	1,410,000	1,420,000
Imports for consumption		225,000	218,000	209,000	231,000	240,000
Consumption, apparent[4]		1,160,000	1,150,000	1,100,000	1,110,000 [r]	1,070,000
Price, December 31:	dollars per pound					
Anatase		0.92-0.94	0.92-0.94	0.92-0.94	0.85-0.95	0.85-0.95
Rutile		0.99-1.02	0.99-1.02	1.00-1.09	0.85-0.95	0.85-0.90
World, production:						
Ilmenite concentrate		4,150,000	5,080,000 [r, 5]	5,220,000 [r, 5]	5,570,000 [r, 5]	5,910,000 [e, 5]
Rutile concentrate, natural		348,000	387,000	377,000 [6]	409,000 [r, 6]	374,000 [e, 6]
Titaniferous slag		2,120,000	2,010,000	2,040,000	2,050,000	1,980,000 [e]

[e]Estimated. [r]Revised.
[1]Data are rounded to no more than three significant digits; except prices.
[2]Excludes consumption used to produce synthetic rutile.
[3]Land duty-paid unit based on U.S. imports for consumption.
[4]Production plus imports minus exports plus stock decrease or minus stock increase.
[5]Includes U.S. production of ilmenite, leucoxene, and rutile rounded to one significant digit to avoid disclosing company proprietary data.
[6]U.S. production of rutile included with ilmenite to avoid disclosing company proprietary data.

TABLE 2
U.S. TITANIUM METAL PRODUCTION CAPACITY IN 2003[1, 2]

		Yearend capacity (metric tons per year)	
Company	Plant location	Sponge	Ingot[3]
Allvac (Allegheny Technologies Inc.)	Albany, OR	--	10,900
Do.	Monroe, NC	--	11,800
Do.	Richland, WA	--	10,000
Alta Group (Honeywell International Inc.)	Salt Lake City, UT	340	--
Howmet Corp. (Alcoa Inc.)	Whitehall, MI	--	3,200
Lawrence Aviation Industries Inc.	Port Jefferson, NY	--	1,400
RMI Titanium Co. (RTI International Metals, Inc.)	Niles, OH	--	16,300
Titanium Metals Corp.	Henderson, NV	8,600	12,300
Do.	Morgantown, PA	--	20,000
Do.	Vallejo, CA	--	800
Total		8,940	86,700

-- Zero.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Estimated operating capacity based on 7-day-per-week full production.
[3]Includes electron-beam, plasma, and vacuum-arc-reduction capacity.

TABLE 3

COMPONENTS OF U.S. TITANIUM METAL SUPPLY AND DEMAND[1]

(Metric tons)

Component	2002	2003
Production:		
Ingot	22,700	35,500
Mill products	19,900 r	21,300
Exports:		
Sponge	2,810	4,990
Waste and scrap	6,000	5,320
Other unwrought[2]	2,650	1,730
Wrought products and castings[3]	6,140	6,510
Total	17,600	18,500
Imports:		
Sponge	10,700	9,590
Waste and scrap	6,270	5,550
Other unwrought[2]	1,680	1,580
Wrought products and castings[3]	2,680	3,640
Total	21,400	20,400
Stocks, yearend:		
Government, sponge (total inventory)	13,200	6,420
Industry:		
Sponge	11,700	8,180
Scrap	3,760	4,320
Ingot	3,200	3,800
Consumption, reported:		
Sponge	17,300	16,800
Scrap	11,600	14,300
Ingot	18,400	27,900
Shipments:		
Ingot (net shipments)	13,100	14,800
Mill products (net shipments):		
Forging and extrusion billet	6,020	5,380
Plate, sheet, strip	5,960	5,200
Rod, bar, fastener stock, wire	3,220	4,520
Other[4]	1,050	549
Total	16,200	15,700
Castings (shipments)	389	459
Receipts, scrap:		
Home	7,570	5,600
Purchased	10,700	11,800

[r]Revised.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Includes billet, bloom, ingot, powder, sheet bar, slab, and other.

[3]Includes castings, foil, pipe, profiles, tube, other wrought and articles of titanium not elsewhere specified or included.

[4]Data for pipe, tube, and other have been combined to avoid disclosing company proprietary data.

TABLE 4

CAPACITIES OF U.S. TITANIUM DIOXIDE PIGMENT PLANTS ON DECEMBER 31, 2003[1, 2, 3]

		Yearend capacity (metric tons per year)		
Company	Plant location	Sulfate process	Chloride process	Total
E.I. du Pont de Nemours & Co. Inc.	De Lisle, MS	--	300,000	300,000
Do.	Edgemoor, DE	--	154,000	154,000
Do.	New Johnsonville, TN	--	380,000	380,000
Kerr-McGee Corp.	Savannah, GA	54,000	110,000	164,000
Do.	Hamilton, MS	--	225,000	225,000
Louisiana Pigment Co. LP	Lake Charles, LA	--	130,000	130,000
Millennium Inorganic Chemicals Inc.	Ashtabula, OH	--	210,000	210,000
Do.	Baltimore, MD	--	50,000	50,000
Total		54,000	1,559,000	1,612,000

-- Zero.

[1]Estimated operating capacity based on 7-day-per-week full production.

[2]Table does not include TOR Minerals International's Corpus Christi, TX, production capacity of about 16,400 metric tons per year of buff TiO_2 pigment that is produced by refining and fine grinding of synthetic rutile.

[3]Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 5

COMPONENTS OF U.S. TITANIUM DIOXIDE PIGMENT SUPPLY AND DEMAND[1]

		2002		2003	
		Gross weight	TiO_2 content	Gross weight	TiO_2 content
Production[2]	metric tons	1,410,000	1,320,000 [e]	1,420,000	1,340,000 [e]
Shipments:[3]	do.				
Quantity	do.	1,530,000	1,430,000	1,430,000	1,350,000
Value	thousands	$2,750,000	$2,750,000	$2,610,000	$2,610,000
Exports	metric tons	540,000	507,000 [e]	584,000	549,000 [e]
Imports for consumption	do.	231,000	217,000 [e]	240,000	226,000 [e]
Stocks, yearend	do.	145,000 [r]	136,000 [r, e]	156,000	146,000 [e]
Consumption, apparent[e, 4]	do.	1,110,000 [r]	1,050,000 [r]	1,070,000	1,000,000

[e]Estimated. [r]Revised.

[1]Data are rounded to no more than three significant digits.

[2]Excludes production of buff pigment.

[3]Includes interplant transfers.

[4]Production plus imports minus exports plus stock decrease or minus stock increase.

Sources: U.S. Census Bureau and U.S. Geological Survey.

TABLE 6
U.S. CONSUMPTION OF TITANIUM CONCENTRATE[1]

(Metric tons)

	2002		2003	
	Gross weight	TiO_2 content	Gross weight	TiO_2 content
Ilmenite and titaniferous slag:[2, 3]				
Pigment	1,280,000	NA	1,280,000	NA
Miscellaneous[4]	16,000	NA	16,700	NA
Total	1,300,000	951,000	1,300,000	959,000
Rutile, natural and synthetic:				
Pigment	464,000	NA	466,000	NA
Miscellaneous[4]	22,900	NA	22,500	NA
Total	487,000	452,000	489,000	453,000
Total concentrate:				
Pigment	1,750,000	NA	1,750,000	NA
Miscellaneous[4]	38,900	NA	39,200	NA
Total	1,780,000	1,400,000	1,790,000	1,410,000

NA Not available.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Includes a mixed product containing rutile, leucoxene, and altered ilmenite.

[3]Excludes ilmenite used to produce synthetic rutile.

[4]Includes alloys, carbide, ceramics, chemicals, glass fibers, titanium metal, and welding-rod coatings and fluxes.

TABLE 7

U.S. CONSUMPTION OF TITANIUM IN STEEL AND OTHER ALLOY[1, 2]

(Metric tons)

	2002	2003
Carbon steel	2,210	2,700
Stainless and heat-resisting steel	3,050 r	3,050
Other alloy steel[3]	965 r	1,140
Total steel	6,230 r	6,890
Superalloys	1,150 r	1,160
Alloys, other than above	752 r	747
Miscellaneous and unspecified	40 r	26
Total consumption	8,170 r	8,820

[r]Revised.

[1]Includes ferrotitanium, scrap, sponge, and other titanium additives.

[2]Data are rounded to no more than three significant digits; may not add to totals shown.

[3]Includes high-strength low-alloy and tool steel.

TABLE 8
U.S. DISTRIBUTION OF TITANIUM PIGMENT SHIPMENTS, TITANIUM DIOXIDE CONTENT, BY INDUSTRY[1]

(Percent)

Industry	2002	2003
Paint, varnish, lacquer	52.6	55.8
Paper	14.9	16.1
Plastics and rubber	26.5	22.5
Other[2]	6.0	5.6
Total	100.0	100.0

[1]Excludes exports.

[2]Includes agricultural, building materials, ceramics, coated fabrics and textiles, cosmetics, food, paper, and printing ink. Also includes shipments to distributors.

TABLE 9

U.S. STOCKS OF TITANIUM CONCENTRATES AND PIGMENT, DECEMBER 31[1]

(Metric tons)

	2002		2003	
	Gross weight	TiO_2 content	Gross weight	TiO_2 content
Concentrates:[2]				
Ilmenite and titaniferous slag	243,000	197,000	244,000	200,000
Rutile, natural and synthetic	81,700	75,400	79,700	73,800
Titanium pigment[3]	145,000 r	136,000 r, e	156,000	146,000 e

[e]Estimated. [r]Revised.

[1]Data are rounded to no more than three significant digits.

[2]Consumer stocks.

[3]Source: U.S. Census Bureau. Producer stocks only.

TABLE 10
PUBLISHED PRICES OF TITANIUM PRODUCTS

		2002	2003
Concentrate:			
Ilmenite, free on board (f.o.b.) Australian ports[1]	dollars per metric ton	85-100	80-100
Rutile, bagged, f.o.b. Australian ports[1]	do.	400-540	430-540
Rutile, bulk, f.o.b. Australian ports[1]	do.	430-470	415-445
Titaniferous slag, Canada, 80% to 95% TiO_2[2]	do.	340-527	444-471
Titaniferous slag, South Africa, 85% TiO_2[2]	do.	445	401
Metal:			
Sponge[2]	dollars per pound	3.64	2.72-3.95
Scrap, turnings, unproccessed[3]	do.	1.07-1.10	1.50-1.70
Ferrotitanium, 70% Ti[3]	do.	2.16-2.18	3.00-3.20
Pigment:			
TiO_2 pigment, f.o.b. U.S. plants, anatase[4]	do.	0.85-0.95	0.85-0.95
TiO_2 pigment, f.o.b. U.S. plants, rutile[4]	do.	0.85-0.95	0.85-0.90

[1]Source: Industrial Minerals.

[2]Landed duty-paid unit value based on U.S. imports for consumption.

[3]Source: Platts Metals Week.

[4]Source: Chemical Market Reporter.

TABLE 11

U.S. EXPORTS OF TITANIUM BY CLASS[1]

Class	2002 Quantity (metric tons)	2002 Value (thousands)	2003 Quantity (metric tons)	2003 Value (thousands)
Metal:				
Unwrought:				
Sponge	2,810	$17,600	4,990	$62,500
Waste and scrap	6,000	14,200	5,320	29,200
Other unwrought:				
Billet	261	6,920	175	4,250
Bloom, sheet bar, slab	1,130	31,500	318	7,410
Ingot	908	12,500	861	10,900
Other[2]	352	11,400	375	13,600
Wrought product and castings:				
Bar, rod, profile, wire	2,680	95,500	2,550	77,400
Other	3,460	148,000	3,960	174,000
Total metal	17,600	338,000	18,500	379,000
Ferrotitanium and ferrosilicon titanium	834	2,340	967	2,930
Ores and concentrates	3,810	2,260	10,300	2,720
Pigment:				
80% or more titanium dioxide pigment	485,000	734,000	518,000	855,000
Other titanium dioxide pigment	26,800	42,600	43,700	65,500
Unfinished titanium dioxide[3]	28,300	46,200	23,000	38,000
Total	540,000	823,000	584,000	958,000

[1]Data are rounded to no more than three significant digits, may not add to totals shown.

[2]Includes titanium powders and other unwrought.

[3]Unmixed and not surface treated.

Source: U.S. Census Bureau.

TABLE 12

U.S. IMPORTS FOR CONSUMPTION OF TITANIUM CONCENTRATE, BY COUNTRY[1]

	2002		2003	
Concentrate and country	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Ilmenite:				
Australia	265,000	$30,700	238,000	$20,200
India	11,000	803	(2)	4
Malaysia	50,500	3,520	10,200	642
South Africa	--	--	18,200	6,620
Ukraine	52,800	5,080	89,100	7,820
Vietnam	15,800	1,180	38,500	2,890
Other	--	--	1,440	1,270
Total	395,000	41,300	395,000	39,500
Titaniferous slag:				
Canada	94,900	41,600	57,700	25,700
South Africa	350,000	152,000	351,000	138,000
Other[3]	68	22	23	10
Total	445,000	194,000	409,000	163,000
Rutile, natural:				
Australia	61,000	28,100	117,000	43,500
South Africa	138,000	57,500	123,000	51,400
Ukraine	11,600	4,430	15,100	5,720
Other[3]	329	130	173	179
Total	211,000	90,100	255,000	101,000
Rutile, synthetic:				
Australia	176,000	56,800	164,000	57,000
Malaysia	2,760	1,620	8,610	4,260
Other	44	13	10	18
Total	179,000	58,500	172,000	61,200
Titaniferous iron ore, Canada[4]	36,600	3,330	18,900	1,390

-- Zero.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Less than 1/2 unit.

[3]Data being verified by the U.S. Census Bureau.

[4]Includes materials consumed for purposes other than production of titanium commodities, principally heavy aggregate and steel-furnace flux. Titaniferous iron ore from Canada is classified as ilmenite under the Harmonized Tariff Schedule of the United States.

Source: U.S. Census Bureau. Data adjusted by the U.S. Geological Survey.

TABLE 13
U.S. IMPORTS FOR CONSUMPTION OF TITANIUM METAL, BY CLASS AND COUNTRY[1]

	2002		2003	
Class and country	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Unwrought:				
Sponge:				
Japan	4,130	$32,800	4,210	$31,400
Kazakhstan	6,010	36,400	4,970	30,200
Russia	525	2,570	270	1,250
Other	73	421	140	625
Total	10,700	72,200	9,590	63,500
Waste and scrap:				
Australia	--	--	17	45
Belgium	149	298	185	735
Canada	198	285	307	831
France	818	2,610	918	3,560
Germany	509	2,030	671	3,090
Israel	120	144	91	327
Italy	174	555	80	257
Japan	2,440	7,360	1,500	4,760
Mexico	474	819	83	387
Russia	8	22	33	148
Sweden	20	85	19	77
Taiwan	197	518	328	1,050
United Kingdom	941	2,500	1,040	3,650
Other	221	572	282	769
Total	6,270	17,800	5,550	19,700
Ingot and billet:				
Germany	209	2,710	86	1,270
Russia	854	9,590	538	4,920
United Kingdom	68	2,470	107	3,210
Other	80	3,060	28	986
Total	1,210	17,800	759	10,400
Powder:				
China	63	360	114	739
Other	12	758	15	1,150
Total	75	1,120	129	1,890
Other:[2]				
France	161	529	149	462
Japan	104	336	282	2,000
Other	128	694	256	1,110
Total	392	1,560	687	3,560
Wrought products and castings:[3]				
Canada	244	6,820	106	4,860
China	85	1,920	53	1,430
Italy	168	4,760	156	4,990
Japan	557	14,100	333	9,650
Mexico	56	844	108	4,840
Russia	1,360	25,300	2,600	40,300
Other	215	8,760	279	16,600
Total	2,680	62,500	3,640	82,600
Ferrotitanium	3,700	9,960	3,160	9,670

-- Zero.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Includes bloom, sheet bar, slab, and other unwrought.
[3]Includes bar, castings, foil, pipe, plate, profile, rod, sheet, strip, tube, wire, and other.

Source: U.S. Census Bureau.

TABLE 14
U.S. IMPORTS FOR CONSUMPTION OF TITANIUM PIGMENT, BY COUNTRY[1]

Country	2002 Quantity (metric tons)	2002 Value (thousands)	2003 Quantity (metric tons)	2003 Value (thousands)
80% or more titanium dioxide:				
Belgium	2,680	$4,030	6,450	$9,440
Canada	62,700	99,600	68,500	112,000
China	6,530	7,790	8,640	10,200
Czech Republic	797	1,250	1,540	2,600
Finland	3,800	7,250	4,430	8,080
France	5,460	8,230	4,470	7,140
Germany	22,300	39,900	27,400	45,300
Italy	11,700	17,300	9,510	14,400
Japan	8,890	17,900	9,690	17,800
Korea, Republic of	5,900	7,180	7,120	9,060
Mexico	8,750	11,900	8,560	13,900
Norway	4,710	7,300	5,650	8,650
Singapore	2,240	3,380	962	1,470
Slovenia	2,760	3,910	1,810	2,700
South Africa	9,700	14,300	9,300	15,300
Spain	7,570	10,800	9,060	14,400
Ukraine	3,200	3,940	--	--
United Kingdom	12,100	18,700	13,600	21,700
Other	1,860 r	3,110 r	942	1,350
Total	184,000	288,000	198,000	315,000
Other titanium dioxide:				
Austria	130	1,840	16	234
Belgium	169	277	18	56
Brazil	85	98	142	197
Canada	1,770	4,750	2,370	7,830
China	577	643	736	1,080
Finland	94	1,170	113	1,380
France	456	1,760	103	351
Germany	728	2,650	668	1,900
India	46	333	146	487
Japan	73	1,070	300	4,790
United Kingdom	131	3,040	188	3,470
Other	244 r	940 r	314	1,270
Total	4,500	18,600	5,120	23,000
Unfinished titanium dioxide:[2]				
Brazil	4,130	5,680	100	145
China	7,380	7,750	10,700	11,400
Czech Republic	3,470	5,060	3,250	5,170
France	17,000	27,500	14,700	21,700
Germany	3,830	10,400	4,730	12,300
Japan	1,090	4,680	999	3,100
Korea, Republic of	2,960	3,680	336	474
Mexico	111	245	126	289
Poland	2,010	2,780	2,200	3,250
Other	1,050 r	1,860 r	460	1,010
Total	43,100	69,600	37,600	58,800
Grand total	231,000	376,000	240,000	397,000

[r]Revised. -- Zero.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Unmixed and not surface treated.

Source: U.S. Census Bureau.

TABLE 15

TITANIUM: WORLD PRODUCTION OF MINERAL CONCENTRATES, BY COUNTRY[1, 2]

(Metric tons)

Concentrate type and country	1999	2000	2001	2002	2003[e]
Ilmenite and leucoxene:[3, 4]					
Australia:					
Ilmenite	1,976,000	2,146,000	2,017,000	1,917,000	2,010,000
Leucoxene	32,000	27,000	30,000	39,000	57,000
Brazil[5]	96,000	123,000	111,113	174,382 r	180,000
China[e]	180,000	250,000 r	300,000 r	750,000 r	800,000
Egypt	130,000	125,000	125,000	125,000 e	125,000
India[e]	378,000	380,000	430,000	460,000	500,000
Malaysia	127,695	124,801	129,750	106,046	95,148 [6]
Norway[e]	600,000	750,000	750,000	750,000	800,000
Ukraine	536,542	576,749	650,000	670,000 e	670,000
United States	W	400,000 [7]	500,000 [7]	400,000 [7]	500,000 [7]
Vietnam	91,000 e	174,000	180,000	180,000 e	180,000
Total	4,150,000	5,080,000 r, [8]	5,220,000 r, [8]	5,570,000 r, [8]	5,910,000 [8]
Rutile:[4]					
Australia	179,000	208,000	206,000	218,000	173,000
Brazil[5]	4,300	3,162	1,791	2,645 r	2,650
India[e]	16,000	17,000	19,000	18,000	18,000
South Africa[e]	100,000	100,000	90,000	100,000	120,000
Ukraine[e]	49,000	58,600	60,000	70,000	60,000
United States	W	(9)	(9)	(9)	(9)
Total	348,000	387,000	377,000	409,000 r	374,000
Titaniferous slag:[10]					
Canada[e]	950,000	950,000	950,000	900,000	875,000
South Africa	1,168,000	1,057,000	1,090,000	1,150,000 e	1,100,000
Total	2,120,000	2,010,000	2,040,000	2,050,000	1,980,000

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data; not included in "Total."

[1]Totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2]Table includes data available through July 15, 2004.

[3]Ilmenite is also produced in Canada and South Africa, but this output is not included here because most of it is duplicative of output reported under "Titaniferous slag," and the rest is used for purposes other than production of titanium commodities, principally steel furnace flux and heavy aggregate.

[4]Small amounts of titanium minerals were reportedly produced in various countries, including Malawi and Turkey. However, information is inadequate to make reliable estimates of output levels.

[5]Excludes production of unbeneficiated anatase ore.

[6]Reported figure.

[7]Includes rutile to avoid revealing company proprietary data. Rounded to one significant digit.

[8]Includes U.S. production, rounded to one significant digit, of ilmenite, leucoxene, and rutile to avoid disclosing company proprietary data.

[9]Included with ilmenite to avoid disclosing company proprietary data; not included in "Total."

[10]Slag is also produced in Norway, Kazakhstan, and Russia, but this output is not included under "Titaniferous slag" to avoid duplicative reporting.